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All-Weather Earth Station Satellite Communication Antennas

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I. INTRODUCTION

The successful TELSTAR® and Relay satellite experiments have led to consideration of the equipment and techniques that might be incorporated in future commercial and military satellite communication systems.

The experiments re-emphasized two facts that had been recognized for some time: (1.) that worthwhile improvement in the earth station receiver sensitivity could be obtained by elimination of the antenna radome, and (2.) that an important practical improvement would be brought about by the location of the communication and tracking equipment on a platform that does not move with the antenna.

These improvements can be achieved by special design of the antenna itself, as indicated in the subsequent papers in this issue. Here the major considerations which motivated that work are reviewed.

II. RADOME

The advantages of having radome protection for the antenna are well known. Foremost is the elimination of wind and weather on the antenna. Second, and also important, is the convenience it permits in antenna construction and maintenance. The disadvantages are also twofold: (1.) extra noise is radiated and reflected from the radome into the re-

ceiver, particularly when the radome is wet by rain or snow, and (2.) interference with local microwave communications can result from extraneous radiation caused by the radome. The interference problem is already significant, and the future promises to make it still more serious.

2.1 *Transmission Degradation*

Measurements† conducted at the Andover Satellite Station during the past three years show that in rain or snow the characteristics of the communications system can be seriously degraded. Measurements of the same nature made by other workers at Bell Telephone Laboratories on antennas without radomes have shown substantially less adverse effects of rain and snow. It can be clearly concluded that the water layer on the radome surface significantly degrades the otherwise good electrical characteristics of the radome.

This degradation occurs in two ways. First, the thermal noise level in the receiving system increases. Temperatures of 160° Kelvin have been measured repeatedly in Andover under wet weather conditions as compared with about 30° Kelvin in dry weather. An uncovered antenna would have increased only about 30° Kelvin under the same conditions. Second, signal loss increases at both the receiving and transmitting frequencies. The loss at the receiving frequency is actually greater than would be expected from the measured increase in the noise temperature. This is because part of the signal is back-scattered into the cold sky and therefore does not give rise to an increase in operating noise temperature. Signal losses of 5 db at 4 gc and even more at a frequency of 6 gc are possible during periods of heavy rain or slushy snow. The losses in case of the uncovered antenna would be substantially lower and entirely predictable from the increase in system noise. The radome-related degradations can make a satellite communications system, which is designed to operate close to the threshold of detection, inoperative for certain periods of time. It is fortunate that in many locations, including the Andover site, these outages are quite rare. Clearly, frequent degradations of reduced severity are also undesirable. A quantitative study of the ground station requirements shows that elimination of the radome will enable the system designer to meet CCIR performance specifications* with a smaller ground antenna than would otherwise be needed.

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† Giger, A. J., 4-gc. Transmission Degradation Due to Rain at the Andover, Maine, Satellite Station, B.S.T.J., this issue, p. 1528.

* CCIR covers the percentage of time a certain noise level should not be exceeded in a telephone channel.

2.2 *Interference*

The susceptibility of an antenna to interfering signals outside the main beam is primarily a function of its side- and back-lobe level. The horn-reflector antenna is known for its extremely low-back lobes which go down to 50 db or more below the isotropic level of the antenna. Such a feature is desirable because it eases the problem of working together with other microwave systems operating in the same frequency band. Site selection for a satellite ground station is simplified since the separation from the next microwave station can be reduced.

The presence of a radome alters the radiation characteristic of an antenna, especially in the low side-lobe region. Although this effect is not appreciable during dry weather for the thin inflatable radome used at the Andover station, it is significant when the radome surface is wet. The degradation of the side-lobe pattern depends on the particular geometrical relation between antenna aperture, radome and surrounding terrain. It is therefore difficult to predict in general.

III. ENVIRONMENTAL PROBLEMS

Exposure to the elements brings about a number of antenna problems. Probably the most serious is that of wind loading. Wind on the antenna structure can cause tracking and control problems, mechanical drive difficulties, and structural distortion. It is important that the antenna be of relatively compact configuration, both to reduce wind cross section and to permit structural rigidity. Ability to cope with the wind problem is a major consideration in the selection, design, and evaluation of all-weather antennas.

The thermal effects brought about by changes in ambient temperatures may be more serious than they are in a protected antenna. The effects of local heating by the sun also are important, therefore, the thermal radiating character and expansion characteristics of the reflector surfaces must be carefully considered.

Rain, snow, and ice problems must also be considered, but the nature of the possible solutions for them is such that they do not strongly influence the basic antenna design. A thin layer of rain water on an antenna reflector does not significantly change the antenna radiation characteristics.

IV. ANTENNA CONFIGURATIONS

At least two antenna configurations appear to be particularly well suited for all-weather use. These have evolved through a series of in-

vestigations of large-aperture, multiple-reflector, horn and cassegrain configurations. The two preferred approaches — the triply-folded horn and the open cassegrain — are discussed in the articles that follow. Each has certain advantages that may be inferred from the measurements, calculations, and practical considerations presented there. Both configurations are meant for operation without a radome, and each permits placement of the communication electronics on a stationary platform.

V. CONCLUSION

The following six papers present recent work that has been motivated by these concepts. If a conclusion can be drawn from the effort as a whole, it is that high-quality, practical, all-weather earth station satellite communication antennas lie comfortably within the boundaries of today's engineering technology.

Errata

A Precise Measurement of the Gain of a Large Horn-Reflector Antenna, D.C. Hogg, and R.W. Wilson, B.S.T.J., *44*, July-August, 1965, pp. 1019–1030.

On page 1023, replace Fig. 3 by Table III. On page 1025, replace 35.10 ± 0.3 db and 35.04 ± 0.03 db by 31.10 ± 0.3 db and 31.04 ± 0.03 db.